FIG. 1

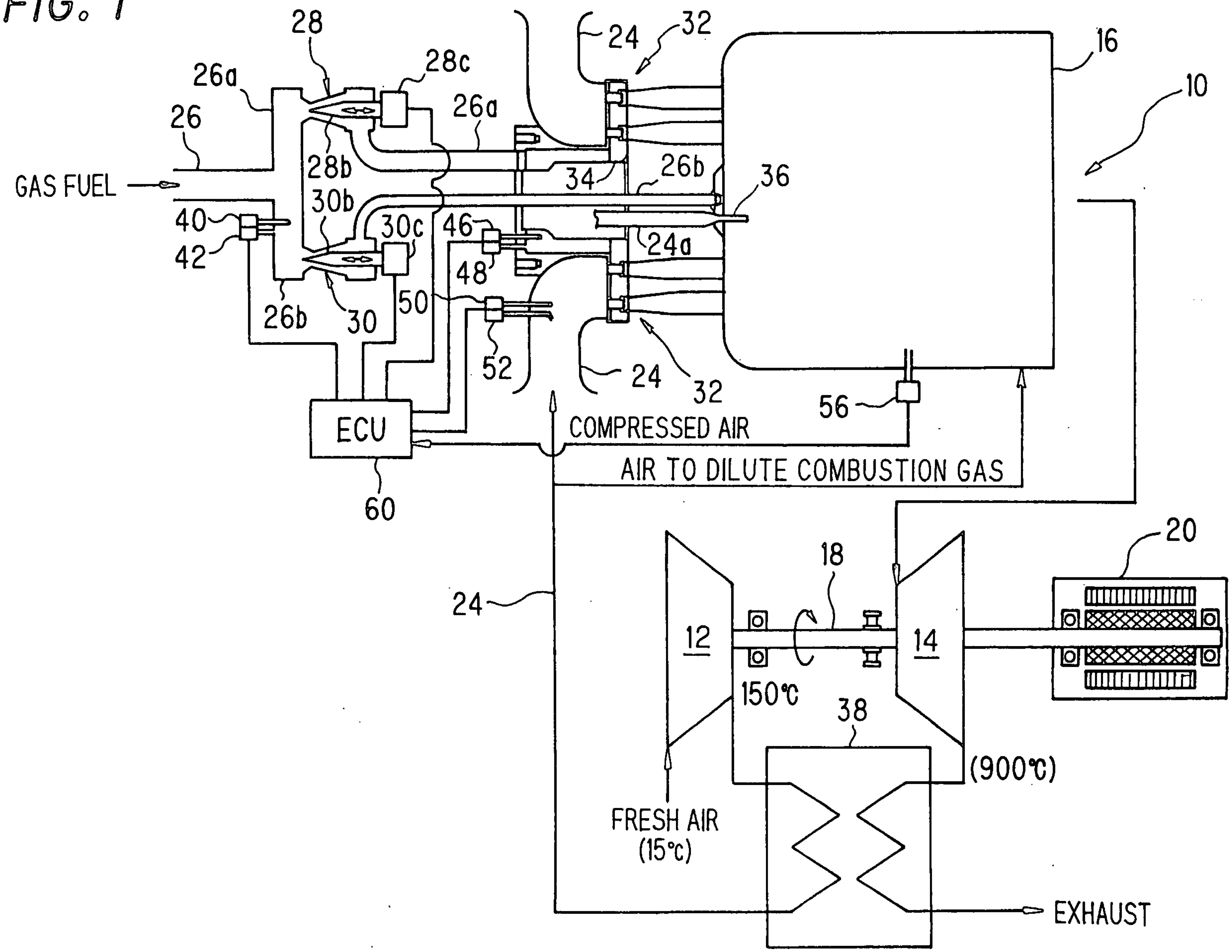

GAS FUEL
26
26a
28
28b
28c
26a
30b
30c
30
26b
40
42
34
26b
36
24a
46
48
50
52
24
32
24
32
16
10
56
ECU
60
COMPRESSED AIR
AIR TO DILUTE COMBUSTION GAS
24
12
18
14
20
150℃
38
(900℃)
FRESH AIR
(15℃)
EXHAUST

FIG. 2

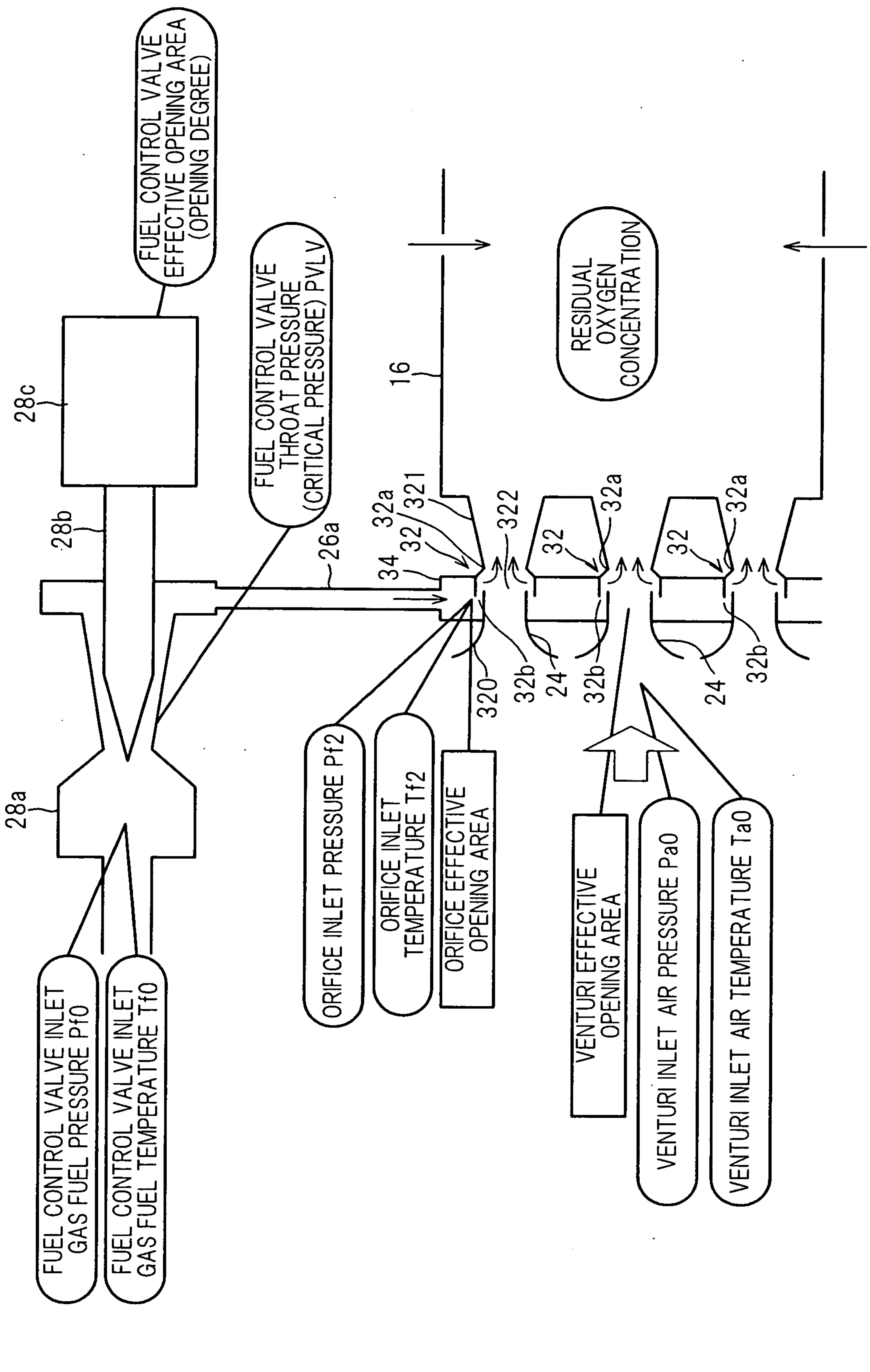

FUEL CONTROL VALVE EFFECTIVE OPENING AREA (OPENING DEGREE)
FUEL CONTROL VALVE THROAT PRESSURE (CRITICAL PRESSURE) PVLV
28c
28b
28a
26a
34
32
32a
321
322
320
32b
24
16
RESIDUAL OXYGEN CONCENTRATION
ORIFICE INLET PRESSURE Pf2
ORIFICE INLET TEMPERATURE Tf2
ORIFICE EFFECTIVE OPENING AREA
VENTURI EFFECTIVE OPENING AREA
VENTURI INLET AIR PRESSURE Pa0
VENTURI INLET AIR TEMPERATURE Ta0
FUEL CONTROL VALVE INLET GAS FUEL PRESSURE Pf0
FUEL CONTROL VALVE INLET GAS FUEL TEMPERATURE Tf0

FIG. 3

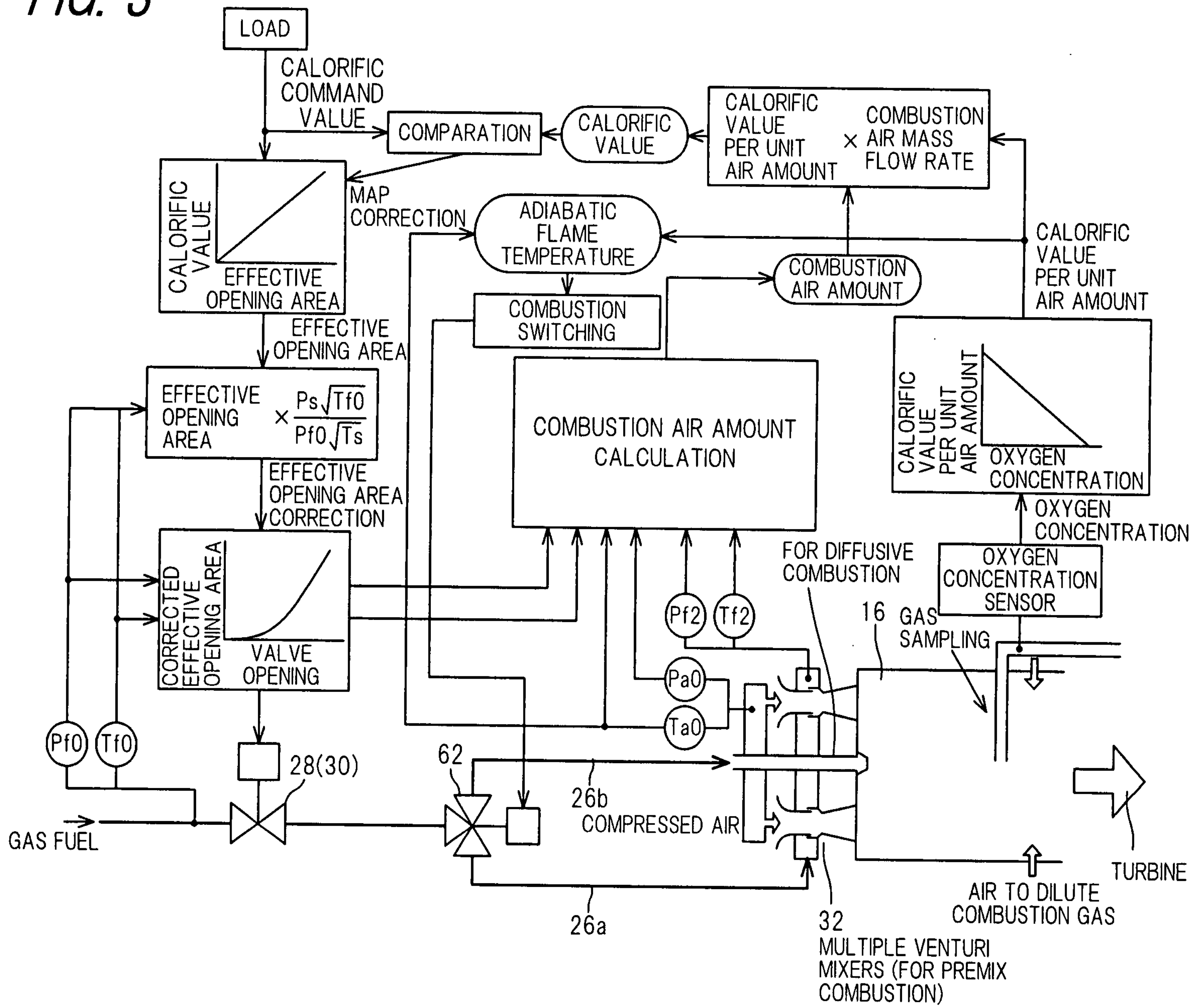

LOAD
CALORIFIC COMMAND VALUE
COMPARATION
CALORIFIC VALUE
CALORIFIC VALUE PER UNIT AIR AMOUNT × COMBUSTION AIR MASS FLOW RATE
CALORIFIC VALUE
EFFECTIVE OPENING AREA
MAP CORRECTION
ADIABATIC FLAME TEMPERATURE
COMBUSTION AIR AMOUNT
CALORIFIC VALUE PER UNIT AIR AMOUNT
COMBUSTION SWITCHING
EFFECTIVE OPENING AREA
EFFECTIVE OPENING AREA × $\frac{Ps\sqrt{Tf0}}{Pf0\sqrt{Ts}}$
COMBUSTION AIR AMOUNT CALCULATION
CALORIFIC VALUE PER UNIT AIR AMOUNT
OXYGEN CONCENTRATION
EFFECTIVE OPENING AREA CORRECTION
OXYGEN CONCENTRATION
OXYGEN CONCENTRATION SENSOR
FOR DIFFUSIVE COMBUSTION
CORRECTED EFFECTIVE OPENING AREA
VALVE OPENING
Pf2
Tf2
16
GAS SAMPLING
Pa0
Ta0
Pf0
Tf0
28(30)
62
26b
COMPRESSED AIR
GAS FUEL
26a
TURBINE
AIR TO DILUTE COMBUSTION GAS
32
MULTIPLE VENTURI MIXERS (FOR PREMIX COMBUSTION)

FIG. 4

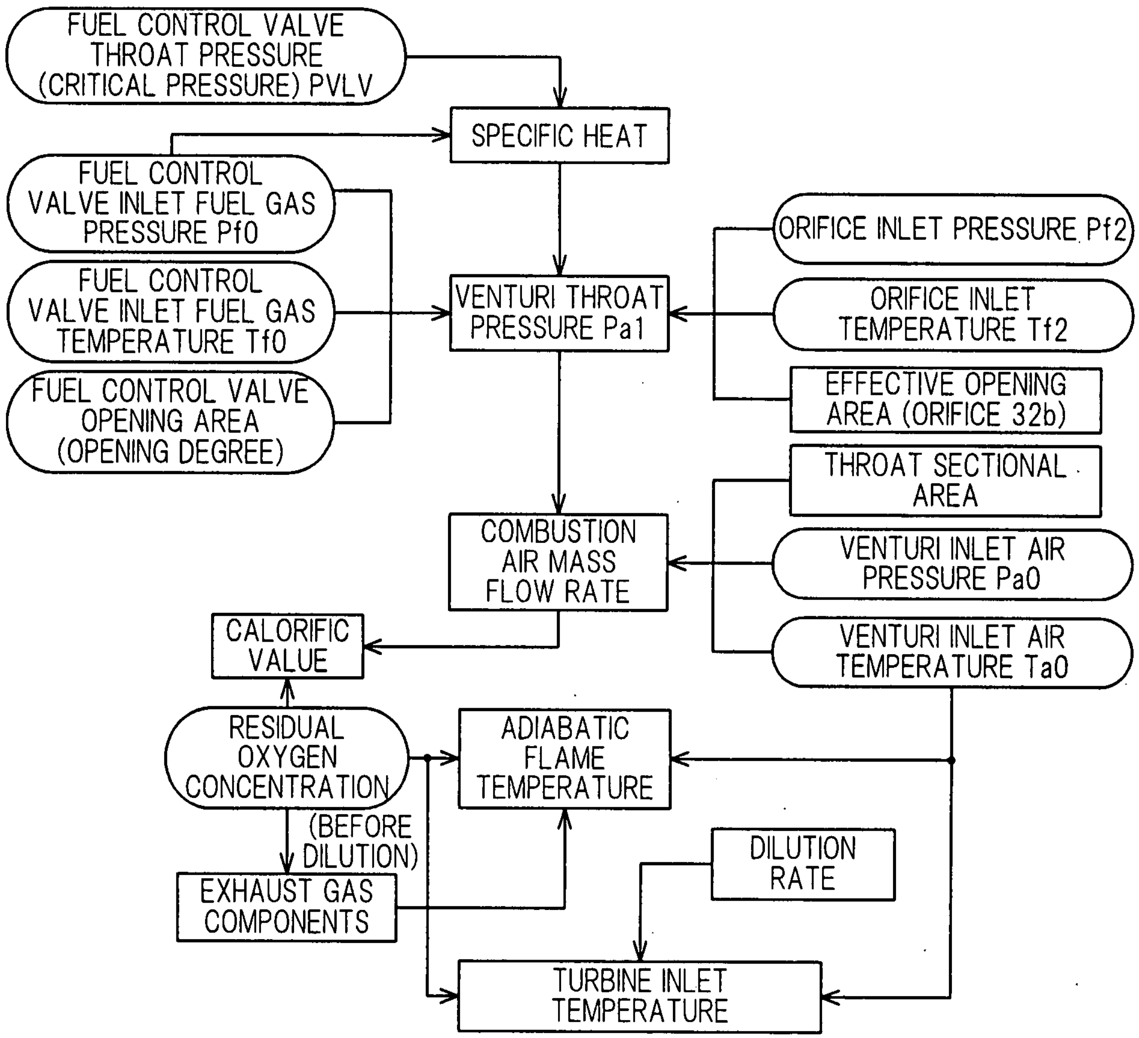

FUEL CONTROL VALVE THROAT PRESSURE (CRITICAL PRESSURE) PVLV
SPECIFIC HEAT
FUEL CONTROL VALVE INLET FUEL GAS PRESSURE Pf0
FUEL CONTROL VALVE INLET FUEL GAS TEMPERATURE Tf0
FUEL CONTROL VALVE OPENING AREA (OPENING DEGREE)
VENTURI THROAT PRESSURE Pa1
ORIFICE INLET PRESSURE Pf2
ORIFICE INLET TEMPERATURE Tf2
EFFECTIVE OPENING AREA (ORIFICE 32b)
THROAT SECTIONAL AREA
VENTURI INLET AIR PRESSURE Pa0
VENTURI INLET AIR TEMPERATURE Ta0
COMBUSTION AIR MASS FLOW RATE
CALORIFIC VALUE
RESIDUAL OXYGEN CONCENTRATION
ADIABATIC FLAME TEMPERATURE
(BEFORE DILUTION)
EXHAUST GAS COMPONENTS
DILUTION RATE
TURBINE INLET TEMPERATURE

FIG. 5

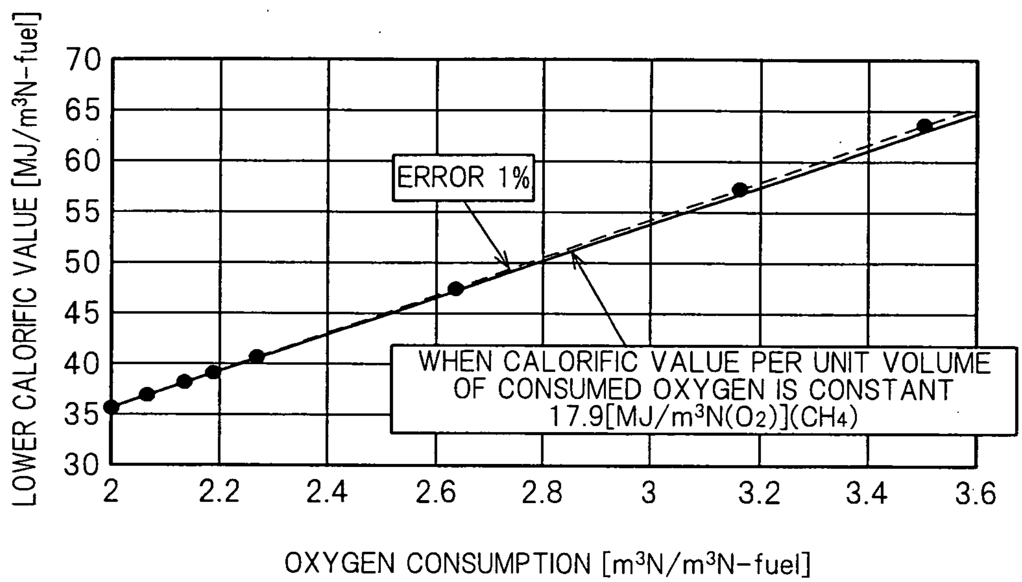

LOWER CALORIFIC VALUE [MJ/m³N-fuel]
70
65
60
55
50
45
40
35
30
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
ERROR 1%
WHEN CALORIFIC VALUE PER UNIT VOLUME OF CONSUMED OXYGEN IS CONSTANT 17.9[MJ/m³N(O2)](CH4)
OXYGEN CONSUMPTION [m³N/m³N-fuel]

FIG. 6

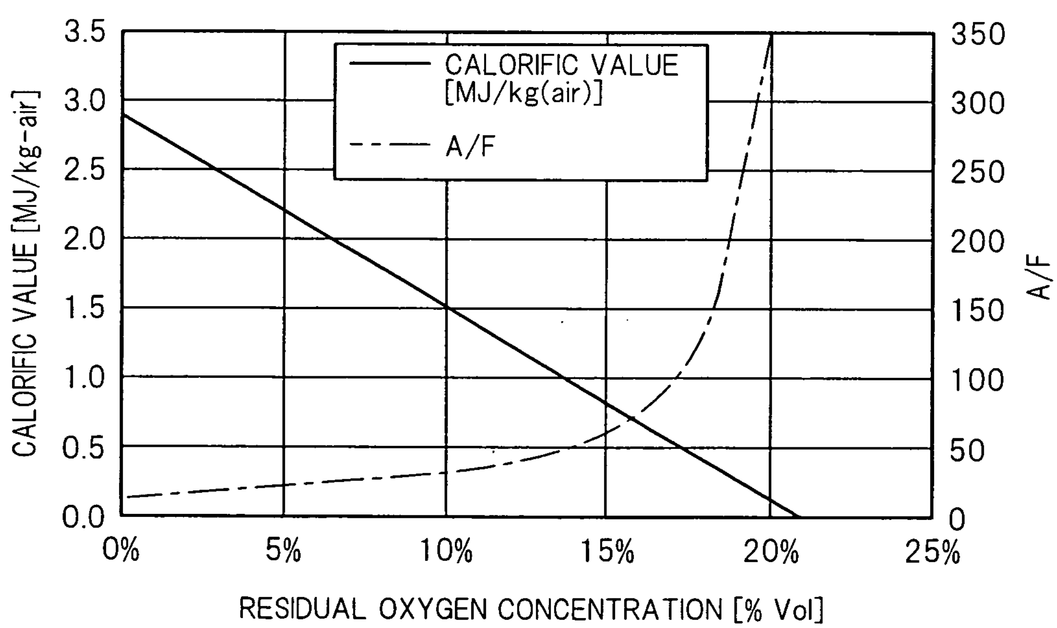
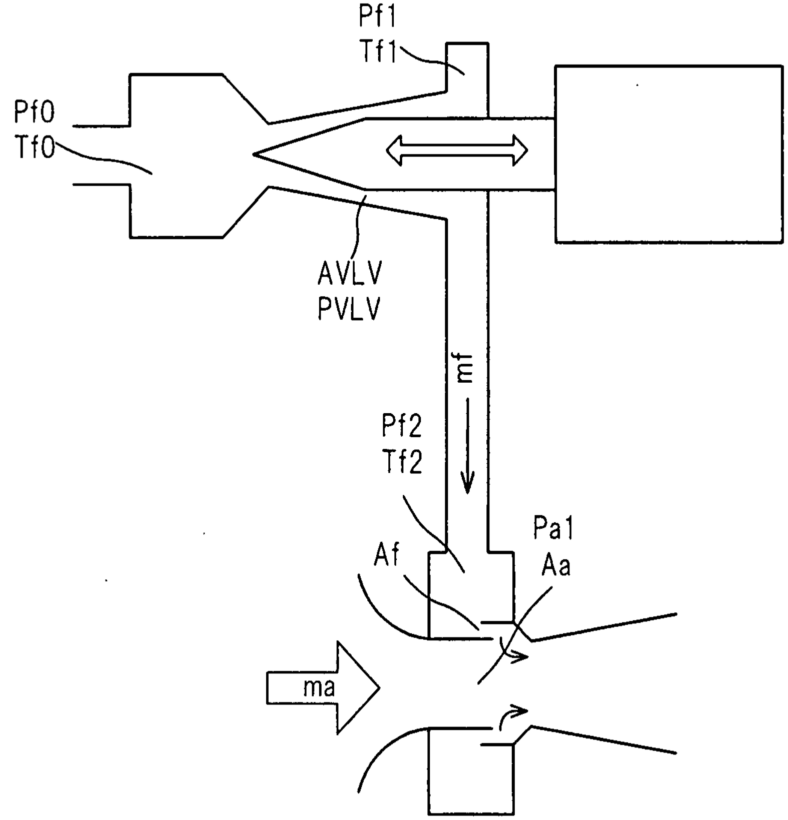

CALORIFIC VALUE [MJ/kg-air]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
350
300
250
200
150
100
50
0
A/F
CALORIFIC VALUE [MJ/kg(air)]
A/F
0%
5%
10%
15%
20%
25%
RESIDUAL OXYGEN CONCENTRATION [% Vol]

FIG. 7

$$mf = \frac{Pf2Af}{\sqrt{RfTf2}} \sqrt{\frac{2\kappa f}{\kappa f-1}\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}} - \left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}}$$

$$ma = \frac{Pa0Aa}{\sqrt{RaTa0}} \sqrt{\frac{2\kappa a}{\kappa a-1}\left\{\left(\frac{Pa0}{Pa1}\right)^{\frac{2}{\kappa a}} - \left(\frac{Pa0}{Pa1}\right)^{\frac{\kappa a+1}{\kappa a}}\right\}}$$



Pf0 : FUEL CONTROL VALVE INLET PRESSURE [Pa]
Pf2 : ORIFICE INLET PRESSURE [Pa]
PVLV : FUEL CONTROL VALVE THROAT PRESSURE [Pa]
Pa0 : VENTURI INLET AIR PRESSURE [Pa]
Pa1 : VENTURI THROAT PRESSURE [Pa]
Tf0 : FUEL CONTROL VALVE INLET TEMPERATURE [K]
Tf2 : ORIFICE INLET TEMPERATURE [K]
Ta0 : VENTURI INLET AIR TEMPERATURE [K]

mf : FUEL MASS FLOW RATE [kg/sec]
ma : AIR MASS FLOW RATE [kg/sec]
AVLV : FUEL CONTROL VALVE EFFECTIVE OPENING AREA [m^2]
Af : ORIFICE INLET EFFECTIVE OPENING AREA [m^2]
Aa : VENTURI THROAT EFFECTIVE OPENING AREA [m^2]
Rf : FUEL GAS CONSTANT [kJ/kg K]
Ra : AIR GAS CONSTANT [kJ/kg K]
κf : FUEL GAS SPECIFIC HEAT
κa : AIR SPECIFIC HEAT

FIG. 8

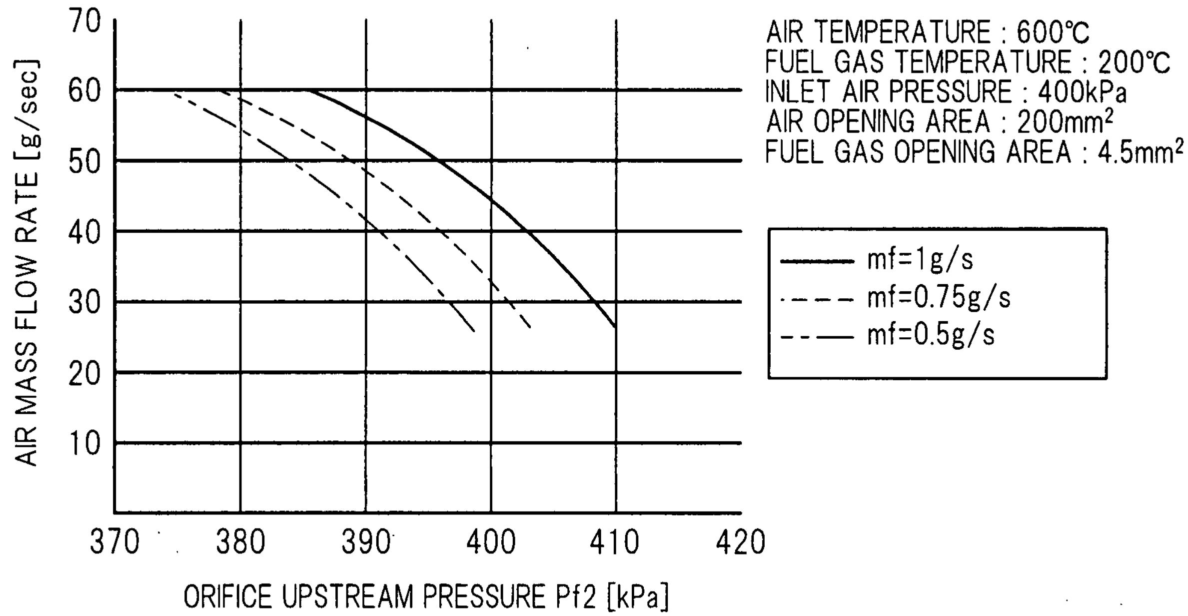

AIR TEMPERATURE : 600℃
FUEL GAS TEMPERATURE : 200℃
INLET AIR PRESSURE : 400kPa
AIR OPENING AREA : 200mm2
FUEL GAS OPENING AREA : 4.5mm2
mf=1g/s
mf=0.75g/s
mf=0.5g/s
AIR MASS FLOW RATE [g/sec]
70
60
50
40
30
20
10
370
380
390
400
410
420
ORIFICE UPSTREAM PRESSURE Pf2 [kPa]

FIG. 9

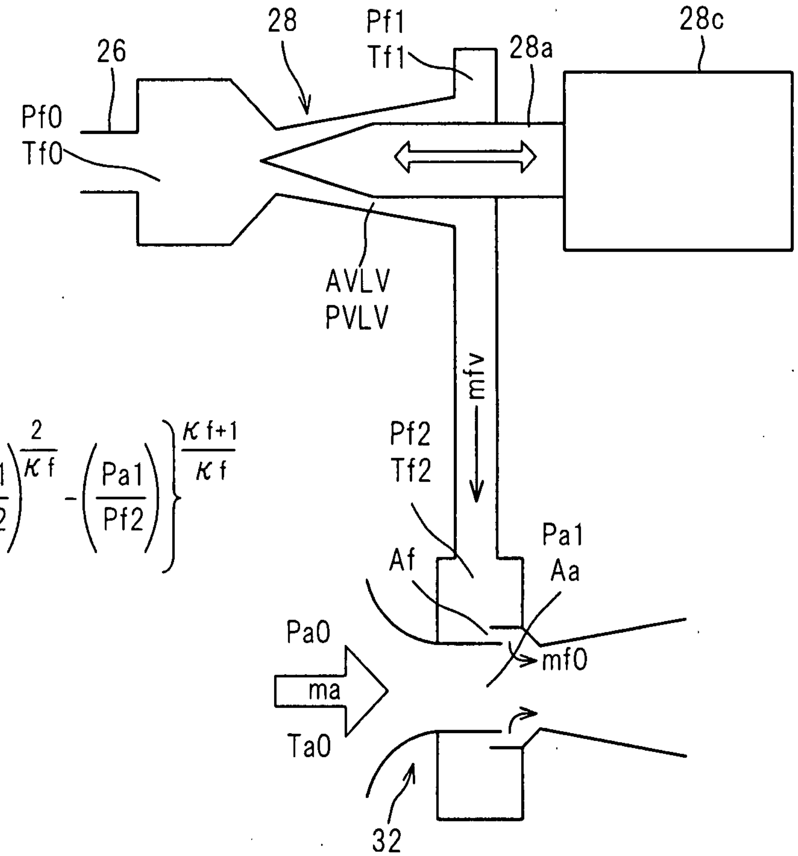
$$mfv = \frac{Pf0AVLV}{\sqrt{RTf0}} M\sqrt{\kappa f}\left(1+\frac{\kappa f-1}{2}M^2\right)^{\frac{\kappa f+1}{2(\kappa f-1)}}$$

$$mf0 = \frac{Pf2Af}{\sqrt{RTf2}} \sqrt{\frac{2\kappa f}{\kappa f-1}\left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}} - \left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}}$$

SINCE VALVE IS CHOKED-FLOW RATE VALVE, MACH IS 1, THIS YIELDS FOLLOWING

$$=\left\{\frac{Pf0AVLV\sqrt{Tf2}}{\sqrt{Tf0}\ Pf2Af}\sqrt{\kappa f}\left(1+\frac{\kappa f-1}{2}\right)^{\frac{\kappa f+1}{2(\kappa f-1)}}\right\}^2 \frac{\kappa f-1}{2\kappa f} = \left\{\left(\frac{Pa1}{Pf2}\right)^{\frac{2}{\kappa f}} - \left(\frac{Pa1}{Pf2}\right)^{\frac{\kappa f+1}{\kappa f}}\right\}$$

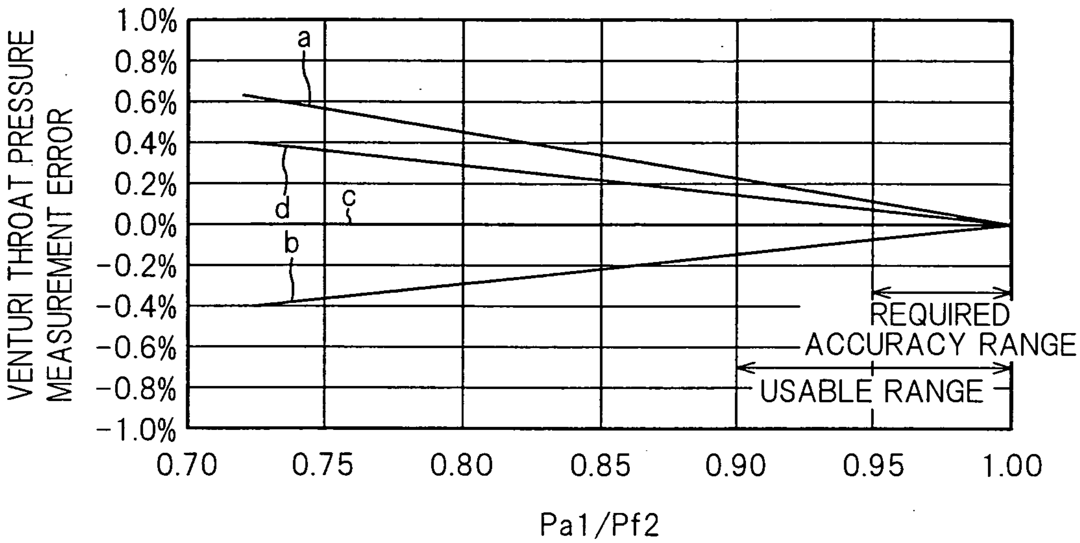
$$ma = \frac{Pa0Aa}{\sqrt{RaTa0}} \sqrt{\frac{2\kappa a}{\kappa a-1}\left\{\left(\frac{Pa0}{Pa1}\right)^{\frac{2}{\kappa a}} - \left(\frac{Pa0}{Pa1}\right)^{\frac{\kappa a+1}{\kappa a}}\right\}}$$



Pf0 : FUEL CONTROL VALVE INLET PRESSURE [Pa]
Pf2 : ORIFICE INLET PRESSURE [Pa]
PVLV : FUEL CONTROL VALVE THROAT PRESSURE [Pa]
Pa0 : VENTURI INLET AIR PRESSURE [Pa]
Pa1 : VENTURI THROAT PRESSURE [Pa]
Tf0 : FUEL CONTROL VALVE INLET TEMPERATURE [K]
Tf2 : ORIFICE INLET TEMPERATURE [K]
Ta0 : VENTURI INLET AIR TEMPERATURE [K]

mf : FUEL MASS FLOW RATE [kg/sec]
ma : AIR MASS FLOW RATE [kg/sec]
AVLV : FUEL CONTROL VALVE EFFECTIVE OPENING AREA [m^2]
Af : ORIFICE INLET EFFECTIVE OPENING AREA [m^2]
Aa : VENTURI THROAT EFFECTIVE OPENING AREA [m^2]
Rf : FUEL GAS CONSTANT [kJ/kg K]
Ra : AIR GAS CONSTANT [kJ/kg K]
κf : FUEL GAS SPECIFIC HEAT
κa : AIR SPECIFIC HEAT

FIG. 10



SAMPLES	SPECIFIC HEAT
a	1.309
b	1.251
c	1.274
d	1.296

FIG. 11

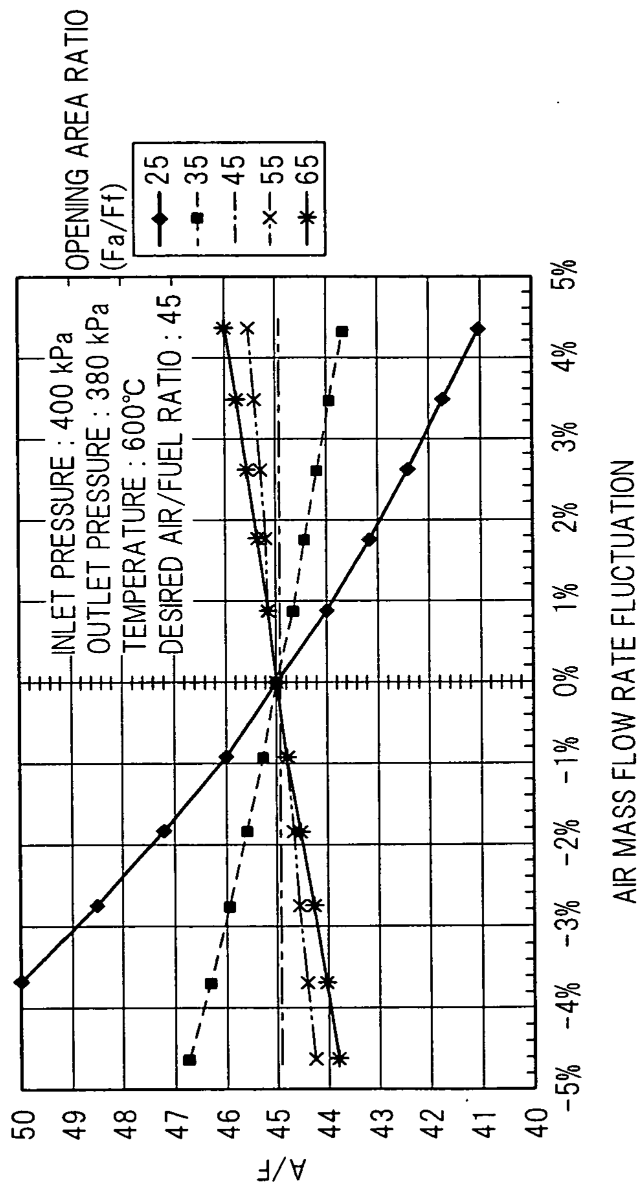

INLET PRESSURE : 400 kPa
OUTLET PRESSURE : 380 kPa
TEMPERATURE : 600°C
DESIRED AIR/FUEL RATIO : 45
OPENING AREA RATIO
(Fa/Ff)
25
35
45
55
65
A/F
50
49
48
47
46
45
44
43
42
41
40
-5%
-4%
-3%
-2%
-1%
0%
1%
2%
3%
4%
5%
AIR MASS FLOW RATE FLUCTUATION

FIG. 12

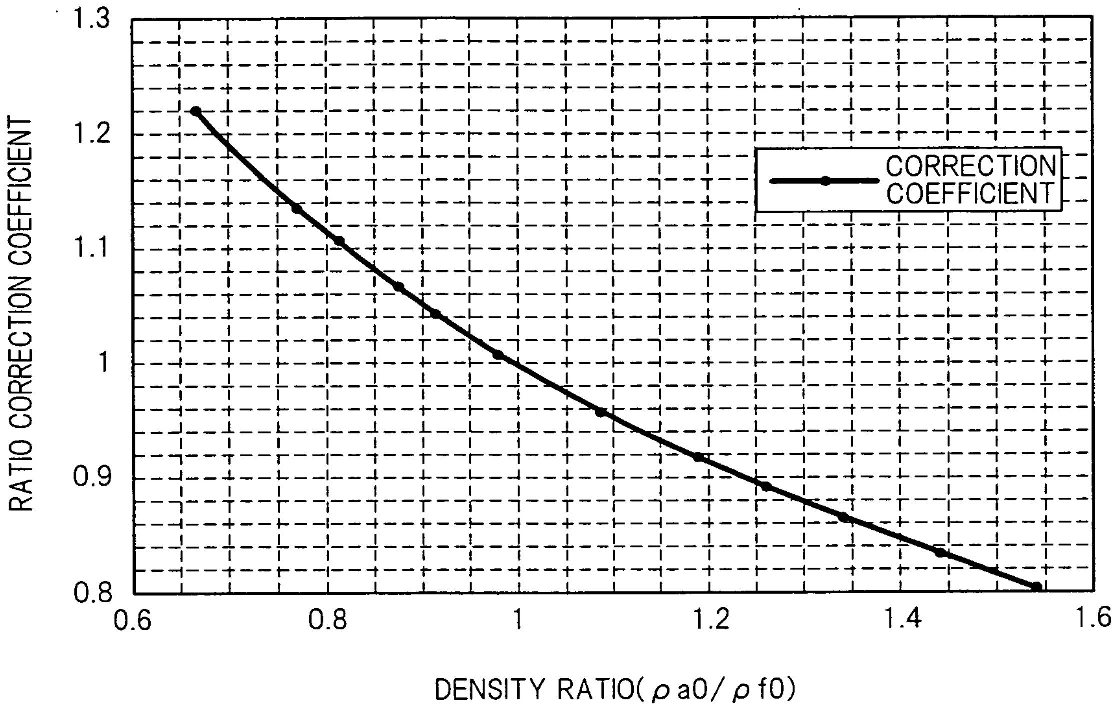
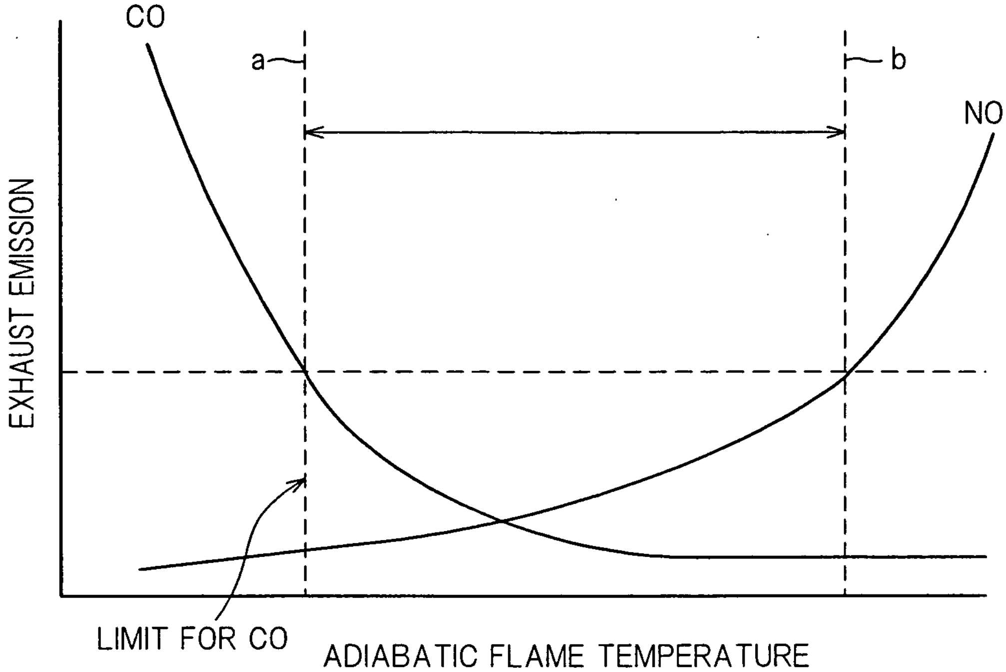

1.3
1.2
1.1
1
0.9
0.8
RATIO CORRECTION COEFFICIENT
CORRECTION COEFFICIENT
0.6
0.8
1
1.2
1.4
1.6
DENSITY RATIO(ρa0/ρf0)

FIG. 13


CO
a
b
NOx
EXHAUST EMISSION
LIMIT FOR CO
ADIABATIC FLAME TEMPERATURE